

August 1995

ELECTRIC VEHICLES

Efforts to Complete Advanced Battery Development Will Require More Time and Funding



**Resources, Community, and
Economic Development Division**

B-260961

August 17, 1995

The Honorable John Glenn
Ranking Minority Member
Committee on Governmental Affairs
United States Senate

Dear Senator Glenn:

Electric vehicles could significantly improve air quality and save oil resources if they replace large numbers of gasoline-powered vehicles. However, electric vehicles will not be widely used unless advanced batteries are successfully developed or some other technological breakthrough occurs to extend their range and lower their cost. In early 1991, after California had mandated electric vehicle sales beginning in 1998, the three domestic automobile companies formed a partnership known as the United States Advanced Battery Consortium to jointly sponsor advanced battery research. Later that year, the Department of Energy (DOE) and representatives of the electric utility industry agreed to work together with the consortium.

The consortium began with a 4-year budget of \$262 million to fund research and testing by battery companies and DOE's national laboratories. DOE was to provide 50 percent of the funding. The other 50 percent was to be provided by the industry—the automobile companies, the utilities, and the battery developers each expected to contribute varying amounts.

This report responds to your request that we determine (1) the progress that the United States Advanced Battery Consortium has made toward reaching its long-term and mid-term goals; (2) the funding that has been spent as of fiscal year 1995 and the additional amounts, if any, that will be needed; and (3) the role of DOE in managing the consortium.

Results in Brief

The United States Advanced Battery Consortium's long-term goal is to develop a battery that will permit electric vehicles to compete fully with gasoline-powered vehicles in terms of performance and cost. To date, the feasibility of such a battery has not been demonstrated. In the interim, the consortium is attempting to develop a mid-term battery that would allow an electric vehicle to travel at least 100 miles under real-world conditions. However, a driving range of 100 miles would not be competitive with the driving range of gasoline-powered vehicles. Moreover, the cost projections

for a battery that meets the consortium's mid-term technical goals substantially exceed the consortium's cost goal. Therefore, it is uncertain whether electric vehicles using such a battery could achieve widespread commercial success, and without such success, environmental benefits and energy savings would be limited.

The consortium's original budget for the period from 1991 through 1995 was \$262 million. However, because of technical problems and delays in negotiating agreements and contracts, only about \$123 million had actually been spent through March 1995. Consortium officials believe that the original budget could sustain the first phase of the research—directed at both long-term and mid-term goals—through 1997. During the first phase, work on the technology to meet mid-term goals is expected to be largely completed. After that, the consortium plans to seek approximately \$38 million more from DOE for a second phase that would run through 1999 and would focus on completing the development of batteries meeting the consortium's long-term goals.

DOE has an active and extensive role in managing the consortium. For example, DOE reviews and approves the consortium's contracts and agreements with battery developers and DOE's national laboratories and participates in the consortium's management and technical committees. In addition, DOE experts provided assistance in choosing advanced battery technologies and selecting qualified contractors. Also, to ensure the allowability of claimed costs, DOE plans a close-out audit of the consortium and will require it to conduct close-out audits of the individual battery developers. On the other hand, DOE has not adequately responded to "lessons learned" during this program that could improve the efficiency of the consortium and other similar cooperative efforts in the future.

Background

In 1990, as part of its effort to meet federal clean air standards, California adopted a requirement that effectively requires automobile companies to offer electric vehicles (EV) for sale there beginning in 1998.¹ Subsequently, similar legislation was passed in several northeastern states. However, the automobile companies believed that without suitable advanced batteries, EVs would be expensive and limited in performance and therefore difficult to sell in the quantities mandated by the states.

¹Technically, the California mandate requires the automobile companies to offer zero-emissions vehicles for sale beginning in 1998. However, EVs appear to be the only vehicles that can achieve zero emissions and that may be reasonably available by 1998.

To address this need for advanced batteries by jointly sponsoring research, Chrysler, Ford, and General Motors established the United States Advanced Battery Consortium (USABC) in early 1991. Because EVs could help reduce mobile-source air pollution while allowing electric utilities to utilize excess capacity during off-peak hours, the Electric Power Research Institute (EPRI), along with several individual utility companies, agreed to participate in the consortium in mid-1991. Then, responding to a legislative mandate to pursue the benefits of EVs,² DOE agreed to cooperate with the consortium's research effort in late 1991.

The relationship between DOE and the three automotive partners in the USABC is governed by a cooperative agreement. This agreement requires DOE to be substantially involved in managing the program and explains how it should be involved. (App. I provides information on DOE's role in managing the consortium.) In addition, the cooperative agreement spells out the details of other important issues, such as the ownership of new technology developed under the program and the potential recoupment, or repayment, of DOE's investment in the program.³ (App. II provides information on repayment provisions applicable to both DOE and the three USABC partners.)

The consortium carries out its work through contracts with seven battery firms and through cooperative research and development agreements (CRADA) with five of DOE's national laboratories. In some instances, the consortium has selected two battery developers to work on the same technology to encourage competition, enhance the chances for success, and potentially provide the automobile companies with multiple battery suppliers.⁴ The five DOE national laboratories were generally selected on the basis of past experience with promising technologies and/or their ability to objectively test battery hardware. (App. IV provides details on the consortium's contracts and CRADAs.)

According to USABC's original budget proposal, the consortium hoped to obtain about 28 percent of the total program budget, or about \$74 million, from the battery developers through cost-sharing provisions in their

²This legislative mandate is contained in the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976. The Energy Policy Act of 1992 reaffirmed this mandate and authorized the Secretary of Energy to enter into cooperative agreements with industry to develop advanced batteries for EV applications.

³Hereinafter, the term "repayment" is used to refer to funds provided to battery companies that are to be paid back to either DOE or USABC.

⁴There is a possibility of a legal dispute between two such developers over the interpretation of patents for a promising mid-term technology. The details of this situation are discussed in app. III.

contracts. However, the cost-sharing percentages vary for each developer, and some developers may eventually join or leave the program. Therefore, the exact cost-sharing percentages for the industry participants will not be known until the end of the program. DOE's national laboratories did not provide any more funding beyond the 50-percent share committed by DOE.

The Feasibility of Long-Term Goals for Advanced Batteries Is Uncertain, While More Achievable Mid-Term Goals Offer Limited Benefits

On the one hand, advanced batteries meeting USABC's long-term goals have not yet been proven technically feasible. On the other hand, batteries meeting the consortium's mid-term goals, while potentially achievable, will not enable EVs to offer performance or costs comparable to those of gasoline-powered vehicles and therefore offer limited market potential. (Information on the consortium's long-term and mid-term goals can be found in app. V.)

USABC's Long-Term and Mid-Term Goals Represent the Combined Thinking of the Automobile Companies and DOE

The automobile companies established USABC because they believed that existing battery technologies would result in EVs with limited driving range—generally well under 100 miles and sometimes as short as 30 miles, depending upon the terrain and weather conditions. Moreover, existing batteries would have to be replaced frequently, greatly increasing the operating cost of EVs. According to DOE and consortium officials, the automakers did not believe such vehicles would be acceptable to consumers and therefore originally proposed that the consortium set its sights strictly on long-term goals. Batteries meeting these goals would store enough energy and power to give EVs the driving range and acceleration of gasoline-powered vehicles at approximately the same lifetime costs. Such EVs would be fully competitive with conventional vehicles.

However, during early discussions with DOE officials in charge of this program, it became clear to the automobile companies that long-term batteries were unlikely to become practical in time to help address the states' EV mandates. In fact, DOE officials who had considerable experience with advanced battery research convinced the automobile companies that considerable uncertainty existed as to whether long-term batteries could be successfully developed. DOE suggested that it would be prudent to also pursue a second set of more readily achievable mid-term goals. DOE stated that (1) mid-term batteries were worth pursuing in their own right because they are significantly better than current technology; (2) developing a

successful mid-term battery could help reestablish a strong domestic battery industry; and (3) mid-term batteries could enable the automakers to gather data on the performance of EVs that would apply to long-term batteries if and when they are developed.

As a consequence, the consortium adopted both the long-term goals originally championed by the automobile companies and a more readily achievable set of mid-term goals recommended by DOE. At that time, consortium officials believed that the mid-term goals could be reached within the 1990s, making mid-term batteries available within the approximate time frame when the states' EV mandates would take effect.

The Benefits of Long-Term Batteries Are Clear, but Their Feasibility Is Uncertain

EVs with long-term batteries are expected to be competitive with gasoline-powered vehicles in terms of performance and cost. If that goal is achieved, such EVs could significantly penetrate the consumer vehicle market. Significant EV sales could reduce petroleum use and increase energy security by replacing imported and domestic petroleum fuels used by conventional vehicles with electricity, which is generated mostly with domestically produced fuels. In addition, the air quality benefits that could follow from replacing petroleum would support important national environmental objectives. The emissions from a relatively small number of stationary electricity generating plants can be more easily controlled than the emissions from a large number of conventional vehicles.

However, it remains unclear whether the feasibility of a long-term battery will be demonstrated. The consortium's original goal was to demonstrate the design feasibility of a long-term battery pack by 1994. Had this goal been achieved, pilot-plant production could potentially have begun several years later, leading to full-scale production early in the next decade. As of mid-1995, long-term battery research still involved small cells with about 1,000 times less energy than a vehicle-size battery pack. However, under the best-case scenario, if breakthroughs are achieved, a battery pack for one type of long-term battery could be proven feasible by 1998. This scenario could lead to pilot-plant production by 2000 and to full production by the middle of the next decade.

The Benefits of Mid-Term Batteries Are Unclear, but Feasibility Has Largely Been Demonstrated

According to USABC officials, batteries that achieve the mid-term goals are likely to be feasible but vehicles with them will have a much shorter driving range than gasoline-powered vehicles and are likely to cost more. The officials added that while such performance may help in meeting the

states' mandates, they do not believe these vehicles will perform well enough to have wide appeal to large numbers of consumers. Consequently, they do not believe that sales in excess of the state-mandated quantities are likely.

The driving range of EVs with mid-term batteries is expected to be about 100 miles under realistic conditions that require extra power for such things as heating, cooling, and climbing hills. According to officials of the consortium's Management Committee, this range will be acceptable only to a limited number of consumers.

Also, automobile companies' market research indicates that consumers will be unwilling to pay a high premium for EVs with limited range. According to the consortium's cost estimates, during the early years of commercialization, before full-scale production is achieved, a mid-term battery pack alone would cost from \$9,000 to \$15,000. Even after full-scale production is achieved, the consortium's latest estimate is that such batteries would cost about \$7,000. This figure exceeds the mid-term cost goal by about \$2,500.⁵

Therefore, particularly during these early years, the automobile companies believe that large subsidies will be needed to sell even the mandated quantities of EVs. Furthermore, according to consortium officials, government and industry have so far been unable or unwilling to offer adequate subsidies. The only currently available federal subsidy, provided under the Energy Policy Act of 1992, is limited to a \$4,000 tax credit per vehicle and may be reduced below that amount for several reasons. Consortium officials also contend that state and local governments have not stepped forward to offer significant subsidies for EVs.

DOE officials in charge of the program are more optimistic than consortium officials about the prospects for EVs with mid-term batteries. In commenting on our draft report, DOE stated that light-duty vans and passenger cars with mid-term batteries can achieve a reliable range from 70 to over 100 miles, respectively, on a single charge. They believe these vehicles will satisfy the needs of many fleet operators as well as private consumers whose daily driving distances are relatively short. For example, DOE officials believe that electric vehicles with mid-term batteries might be successful in niche markets, such as electric utility fleets. They also believe that full-scale production and lower cost can be achieved relatively

⁵The consortium's cost goal for mid-term batteries is less than \$150 per kilowatt hour. This equates to \$4,500 or less for a battery pack of 30 kilowatt hours, which the consortium views as sufficient for a typical EV.

quickly through such strategies as developing other customers for mid-term batteries in the recreational vehicle and foreign EV markets. Using this approach, DOE officials have estimated that with the federal incentive, an EV with a mid-term battery will exceed the cost of a gasoline-powered vehicle by only about \$2,500. They believe sales incentives from the automobile companies themselves would be sufficient to address this remaining cost increment.

Despite DOE's estimates, consortium officials doubt that EVs with mid-term batteries can achieve any significant market penetration. While mid-term batteries would extend the range of EVs beyond that provided by using existing batteries, the consortium and DOE both agree that these EVs would not be comparable in performance to gasoline-powered vehicles and would cost more. Both the consortium and DOE also believe that significant market penetration would be required to achieve any widespread benefits in terms of energy security or environmental improvement.

Despite their concerns about the market's acceptance of mid-term batteries, USABC officials concluded that they are a necessary step toward the ultimate goal of commercializing long-term batteries. Therefore, the consortium has continued to pursue the mid-term goals and has made progress toward developing a workable mid-term battery.

The consortium originally planned to demonstrate the feasibility and begin the pilot-plant production of mid-term batteries by 1994; full commercial production (over 10,000 battery packs a year) could then have begun by approximately 1998. As of mid-1995, most aspects of technical feasibility had been demonstrated for one mid-term battery technology. However, the developers needed more time to demonstrate that the battery could meet the goal of lasting 5 years. The consortium now expects that the pilot-plant production of this battery will begin in 1996 and that full production will begin in 2000 or 2001. Hence, existing lead-acid batteries are likely to be used during the first few years of the states' EV mandates that will begin in 1998.

DOE and USABC officials attributed their inability to meet the original target dates for both mid-term and long-term batteries to two factors. First, lengthy contract and CRADA negotiations delayed the start of some work for as much as a year. For example, negotiations with battery companies were delayed because of their reluctance to agree to consortium-required cost-sharing provisions and DOE-required patent provisions that threatened companies' ownership of previously developed background technology.

Second, technical challenges proved to be more difficult than anticipated, causing delays of a year or more. Each of the technologies under development has presented significant technical barriers, including the high cost of certain materials, the difficulty of fabricating battery components to meet demanding specifications, and a shortened battery life caused by corrosive materials.

USABC Believes It Can Stretch Current 1995 Budget Through 1997, Then Seek \$38 Million More

Phase I of the USABC program began in 1991 and has included research on both mid-term and long-term batteries. Consortium officials believe that the budget originally planned for Phase I can carry the program through 1997, during which time most of the work on mid-term batteries would be completed. The consortium has also formulated a Phase II plan that would focus primarily on continuing research on long-term batteries through 1999.

The consortium's original budget was \$262 million for 1991 through 1995. However, as explained above, progress has been delayed because of difficulties in negotiating agreements and contracts and greater-than-expected technical barriers. Consequently, spending has been slower than anticipated. As of March 1995, about \$123 million, or less than half the total budget, had been paid out by the consortium for all expenses.

Meanwhile, through June 1995, planned expenditures included a total of about \$181 million of Phase I funds that have been obligated through contracts and CRADAs, of which about 45 percent was allocated to mid-term projects and 55 percent to long-term projects. Additionally, in-kind contributions and general and administrative expenses in connection with these obligations were expected to total about \$11 million by the end of Phase I. (App. VI contains information on appropriations received by DOE to cover its 50-percent share of these expenditures.)

USABC officials hope to extend the cooperative agreement beyond 1995 to complete the development effort. The consortium believes the original \$262 million will be sufficient to continue the work through 1997. During this period, Phase I, including most of the work on mid-term battery development, would be completed, and Phase II would begin, focusing primarily on the continued development of long-term batteries. During 1998 and 1999, the consortium hopes to continue Phase II to complete the work on long-term batteries. Phase II would require a total of about \$81 million in additional funds for those 2 years. The consortium plans to ask DOE to provide almost half of that amount—about \$38 million—or

about \$19 million a year. DOE is aware of this plan but has not yet endorsed it, pending a more detailed explanation from consortium officials of how these funds would be used by the battery developers.

According to USABC officials, Phase II of the program depends upon fully funding Phase I, which is now somewhat in jeopardy. The consortium's original budget called for the battery development companies to share a portion of the program's total costs. However, early in the program, the consortium decided to significantly increase the amount of testing and battery development work to be performed by DOE's national laboratories, thereby reducing the amount of work to be done by the battery companies. Since the laboratories do not contribute any share of the costs beyond DOE's 50-percent share, this change has resulted in a shortfall of about \$19.6 million that would have been provided by battery companies, had they done the work now being performed by the laboratories. When combined with lost matching funds that would have come from DOE, the \$19.6 million shortfall becomes about \$39 million, dropping the program's total funding from the planned \$262 million to only \$223 million.

Consortium officials stated that the automobile companies are willing to increase their contribution enough to restore full funding for Phase I if the government makes a commitment to Phase II. However, they indicated that the automobile companies may be unwilling to commit these extra funds if Phase II is not approved. Consortium officials also stated that they will need a clear signal by approximately October 1995 as to whether the Congress intends to provide funding for Phase II, or they will have to begin cutting back on existing contracts to avoid jeopardizing their ability to complete any of them. However, they believe that cutting back on work by specific battery developers this year would require decisions based on expert opinion rather than on actual test results, which are not yet available. As a result, companies that might develop a viable advanced battery, given more time, might be prematurely eliminated from the program. Without funding for Phase II, consortium officials expect that, at best, just one of the three current long-term contracts could be continued. They believe such a cutback would seriously diminish the chances for success in the long-term program.

DOE Has Active Role in USABC Management, but Greater Attention to Lessons Learned Could Improve the Program

According to DOE and industry officials, DOE program officials have made valuable contributions to the management of the consortium. In addition, DOE contracting officials plan audits to ensure that the program's costs are adequately accounted for. Nonetheless, greater attention by DOE to lessons learned during the program could improve the efficiency of both USABC and similar cooperative efforts in the future.

DOE Maintains an Active Role in Overseeing USABC's Progress

Both the members of the USABC Management Committee and the DOE officials in charge of the program stated that DOE has been actively involved in managing and overseeing the consortium. DOE helps manage the consortium through participation in the Management Committee, which is responsible for key decisions such as selecting the technology to be developed and contractors. This committee includes executives from each of the three automobile companies and representatives of DOE and EPRI. Technically, DOE does not have voting authority on the committee. However, an automobile industry committee member stated that no important decisions are made without the concurrence of DOE's representative. Moreover, DOE officials said that their control of half the program's funding gives them de facto veto power over key management decisions.

On a more technical level, DOE personnel provide oversight and guidance to the consortium through representation on the Technical Advisory Committee, which supports the Management Committee. Besides actively participating in meetings of the Technical Advisory Committee, DOE experts also serve as members of individual working groups that oversee the work of each battery developer and national laboratory involved in the program.

DOE Plans to Audit Cost-Sharing Claims

Ensuring the allowability of costs is a concern because the costs submitted by the consortium and the developers are used as the basis to compute DOE's 50-percent share of the program's costs. The consortium partners and developers are required to make significant cost-sharing contributions to the program.⁶ Ensuring that only allowable costs are submitted is important in order to avoid reimbursing the USABC partners or

⁶Under USABC's original budget proposal, the battery developers were expected to contribute about 28 percent—or about \$74 million—to the total cost of the program. The automobile companies were expected to contribute about 17 percent.

the developers for costs that should be covered by their own contributions.

During the course of our review, we raised a potential concern about the adequacy of the audit coverage of the costs claimed by the consortium and the battery developers. DOE contracting officials told us that an audit to determine the allowability of costs claimed by the consortium is not required but that one might be done at the conclusion of the program. The DOE officials also said that USABC is responsible for determining the allowability of costs claimed by the battery developers, with technical input from DOE's program manager. USABC Management Committee officials said that the primary responsibility for ensuring the allowability of the developers' costs lies with the individual USABC program managers, who are primarily automobile company employees. They also said they were not certain whether the consortium would conduct formal close-out audits of the battery developers.

At the conclusion of our review, the DOE contracting officer responsible for the USABC program told us that there would definitely be a close-out audit of the consortium and that this audit would include a review of the costs claimed by the battery developers and reported to the consortium. The contracting officer also said that DOE would initiate individual audits of the developers' books, if necessary. In addition, the contracting officer said that the consortium is required by the regulations governing the cooperative agreement to conduct close-out audits of battery developers' costs and, if necessary, to request DOE's assistance in conducting such audits.

Lessons Learned Have Not Received Adequate Consideration

Greater attention to lessons learned during the USABC program could improve cooperative efforts between DOE and the industry. After a meeting of industry and government officials initiated by DOE in July 1993, the problems encountered and recommended actions to address them were compiled by a consultant in a "lessons learned" document.⁷ Most of the problems identified involved industry's perceptions of barriers created by DOE or overall government policies and procedures.

Many of the 17 items discussed in the document concerned delays. For example, the document pointed out that the program was delayed by the lengthy negotiation of contracts. Contributing to these delays was the

⁷Lessons Learned Under the United States Advanced Battery Consortium (USABC), DOE (Washington, D.C.: 1993).

reluctance on the part of battery developers to agree to certain DOE-required provisions, such as “march-in” rights that enable DOE to take ownership of technology if it is not commercialized by the developer within a suitable time period. In addition, industry officials attributed delays to DOE’s policy of avoiding direct involvement in contract negotiations but subsequently insisting on reviewing and approving each contract provision and modification. In the case of CRADAS, industry officials contended that multiple levels of review and approval by several DOE field offices and by DOE headquarters resulted in additional delays in the program.

The lessons learned document included several industry-recommended actions to be taken by DOE to eliminate or minimize these causes of delays, including (1) developing a new approach to issues involving the ownership and use of technology that would be specifically applicable to cooperative agreements; (2) allowing DOE contracting officers to actively participate in negotiations with contractors; and (3) streamlining the process of reviewing and approving contracts and agreements.

DOE officials who participated in a meeting devoted to the lessons learned agreed with some of the recommendations, such as one that called for DOE to develop a model CRADA to standardize the process of negotiating CRADAS with the various DOE national laboratories. Subsequently, a model CRADA was developed. However, these DOE officials also argued that some of the recommended actions were unnecessary or inappropriate. For example, they did not agree that provisions about the government’s ownership and use of technology were the main reason for delays in negotiating contracts, nor did they believe that a new approach to these provisions was imperative. Also, the DOE officials argued that it would be a conflict of interest for contracting officers, who are responsible for approving contracts, to also take part in negotiating those contracts.

In subsequent discussions with us, however, several DOE officials endorsed certain of the recommendations in the lessons learned document. For example, the patent attorney overseeing USABC’s affairs in DOE’s Chicago Operations Office agreed with the assertion that there is a need for new rules governing the government’s ownership and use of technology for programs like the USABC program. Also, the director of DOE’s Office of Procurement, Assistance, and Property stated that industry’s call for greater involvement in negotiations by DOE contracting officers contained some logic and was worth considering. In addition, the director of DOE’s Electric and Hybrid Propulsion Division told us that new procurement

rules, such as those recommended in the lessons learned document, are needed to provide greater flexibility for cooperative agreements.

According to DOE program officials, implementing many of the recommendations would require action by other DOE offices, such as those responsible for procurement and patent rights. They said they had sent copies of the lessons learned document to these offices and encouraged them to implement changes where feasible. However, when we contacted officials of these other offices, they indicated that the document's recommendations had not received serious consideration. The procurement official cited above told us that program officials had not built a convincing enough case for the changes they sought by merely distributing copies of the lessons learned document.

Thus, it appears that uncertainties and/or disagreements within DOE about the utility or appropriateness of some recommendations in the lessons learned document were not addressed, and others were not carefully evaluated by DOE officials in a position to effect changes. Consequently, it is uncertain which, if any, of the recommendations would have been practical to implement or what improvements to the USABC program might have resulted from their implementation. Moreover, by not following through on the lessons learned in this program, DOE may have missed an opportunity to improve the efficiency of future cooperative efforts with industry.

Conclusions

Advanced batteries that would make electric vehicles fully competitive with gasoline-powered vehicles have not yet been proven to be feasible, although DOE and United States Advanced Battery Consortium officials believe that continued research on these batteries is justified. Progress has been made toward developing mid-term battery technologies, but these batteries will probably not be available until several years after the states' mandates for the sale of electric vehicles begin in 1998. Because the batteries will not make electric vehicles fully competitive with gasoline-powered vehicles, the energy security and environmental benefits of mid-term batteries appear limited.

To reach the goal of developing a long-term advanced battery, consortium officials believe that approximately \$38 million in additional federal appropriations will be needed. If these funds are received, the consortium hopes that pilot-plant production can begin by 2000. But if there is no indication that the extra funds will be available, consortium officials

believe that some contracts may have to be terminated before sufficient data are available to aid in decision-making. They believe that such action would significantly reduce the chances for the successful development of a long-term battery.

DOE did not follow up on several lessons learned during this program that could benefit future efforts based on similar cooperative agreements. Industry officials believe that certain actions, such as streamlining DOE's contract review procedures, could help prevent programs like the United States Advanced Battery Consortium program from falling behind schedule.

Recommendation

GAO recommends that the Secretary of Energy give more careful consideration to the document entitled Lessons Learned Under the United States Advanced Battery Consortium to determine whether any of its recommendations should be implemented and develop an action plan for implementing those that are warranted.

Agency Comments and Our Evaluation

We provided a draft of this report to DOE for written comments. (These comments are contained in app. VII.) While agreeing with our characterization of the feasibility of long-term batteries, DOE said that our draft report underestimated the potential prospects for the technology used for mid-term batteries. We had stated in the draft report that DOE officials are more optimistic about mid-term batteries than consortium officials and had summarized their reasons for being optimistic. DOE's written comments provide more detailed information on this point, some of which we have added to our final report. With respect to information in the draft report summarizing the consortium's plan to seek additional funds for the program, DOE stated that it views the plan as prudent and well considered. DOE accepted our recommendation that it give more careful consideration to implementing changes called for in the document identifying lessons learned under the program. DOE also provided suggested editorial changes, which we have made where appropriate.

To respond to your request, we met with officials of DOE, USABC, the electric utility industry, battery development contractors, and national laboratories. We also had discussions with representatives of an independent EV manufacturer and a producer of currently available EV batteries. We also obtained and reviewed pertinent documentation from

these sources. We conducted our review between September 1994 and June 1995 in accordance with generally accepted government auditing standards. (App. VIII provides a more detailed discussion of our objectives, scope, and methodology, including a complete listing of the persons contacted during our review.)

Unless you publicly announce its content earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies of this report to interested congressional committees, the Secretary of Energy, and the USABC Management Committee. We will make copies available to others upon request.

Please call me at (202) 512-3841 if you have any questions. Major contributors to this report are listed in appendix IX. A list of GAO products related to this issue appears on the last page of this report.

Sincerely yours,

A handwritten signature in cursive script that reads "Harry R. Tinsley".

Victor S. Rezendes
Director, Energy and
Science Issues

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Abbreviations

CRADA	cooperative research and development agreement
DOE	Department of Energy
EPRI	Electric Power Research Institute
EV	electric vehicle
USABC	U.S. Advanced Battery Consortium

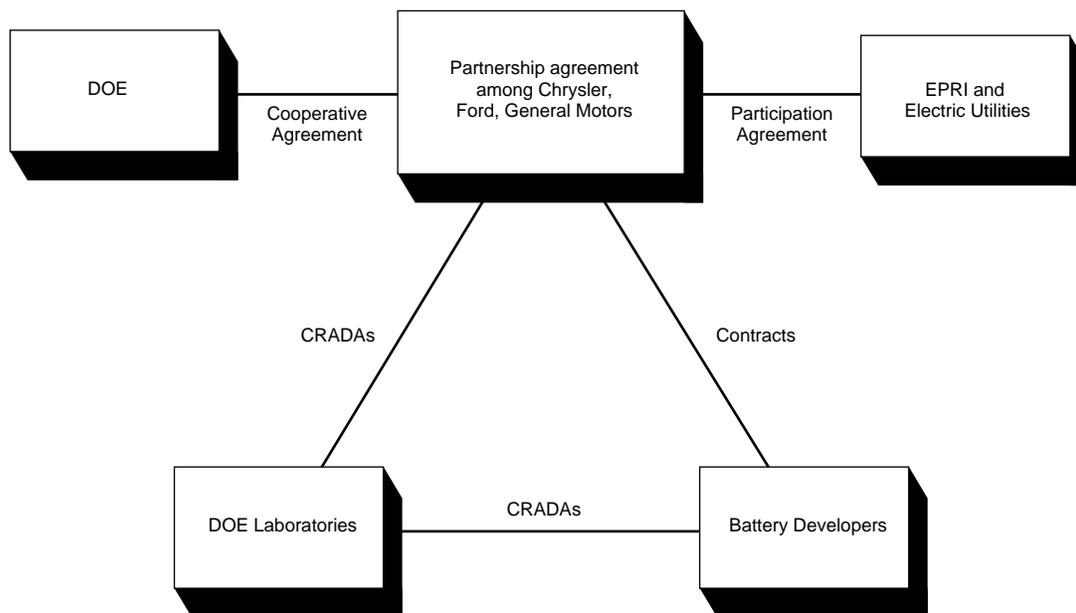
DOE's Role in USABC's Management

The U.S. Advanced Battery Consortium (USABC) established a framework for cooperation among various organizations seeking to develop advanced batteries for electric vehicles (EV) in the United States. This framework was established by a series of agreements among the stakeholders—automobile companies, the Department of Energy (DOE), electric utilities, battery developers, and DOE's national laboratories. This appendix summarizes these agreements, the management structure resulting from them, and DOE's role in that structure.

USABC's Agreements

The relationships between the parties in USABC are governed by a partnership agreement, a participation agreement, and a cooperative agreement, all signed during 1991. Subsequently, USABC signed development contracts with battery companies and cooperative research and development agreements (CRADA) with DOE's national laboratories. Figure I.1 illustrates the relationships established by these agreements.

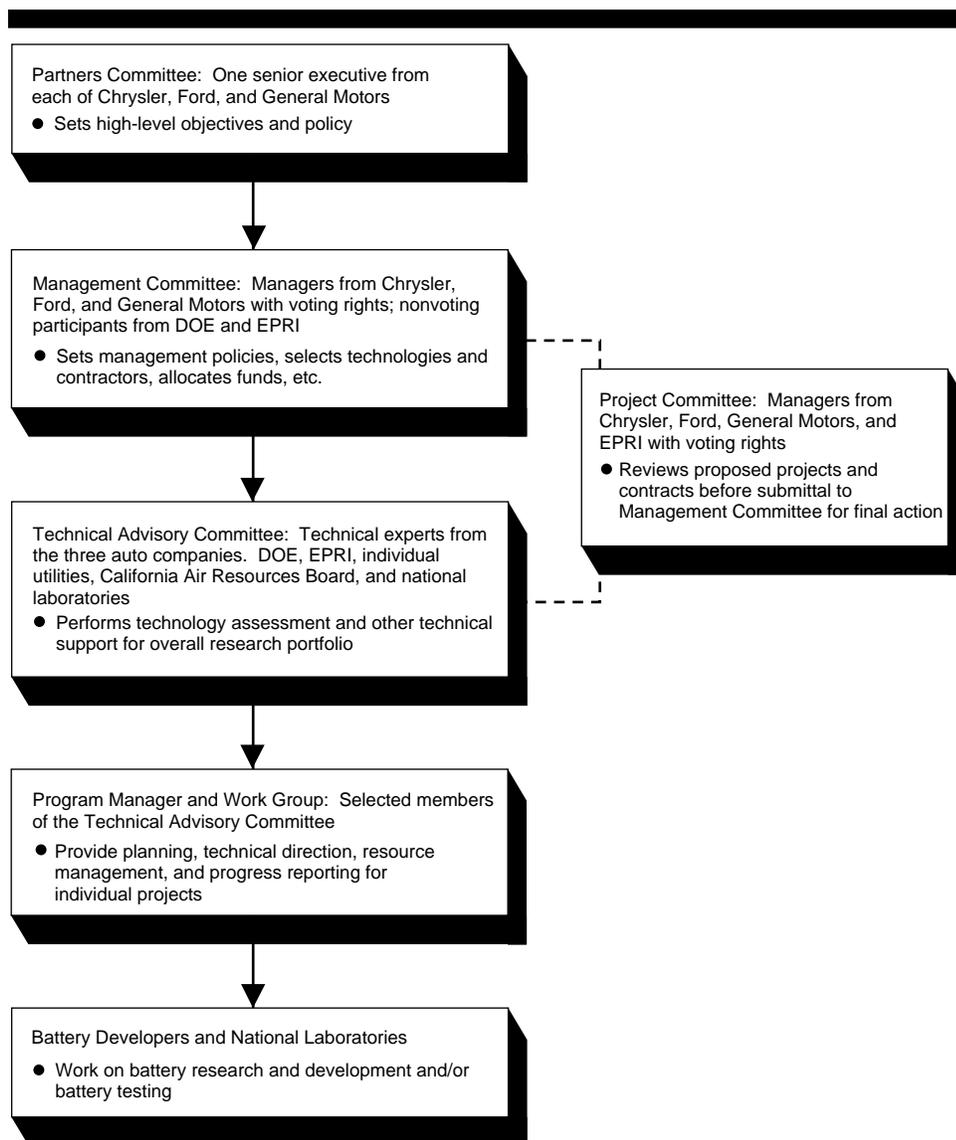
Figure I.1: USABC's Agreements



USABC's Structure

USABC's organizational structure includes four committees—the Partner's Committee, the Management Committee, the Project Committee, and the Technical Advisory Committee, each responsible for different aspects of USABC's decision-making process. In addition, each battery development contract and laboratory CRADA is assigned a battery technology work group, headed by a program manager. Figure I.2 illustrates how these structures contribute to accomplishing USABC's work.

Figure I.2: How USABC Does Its Work



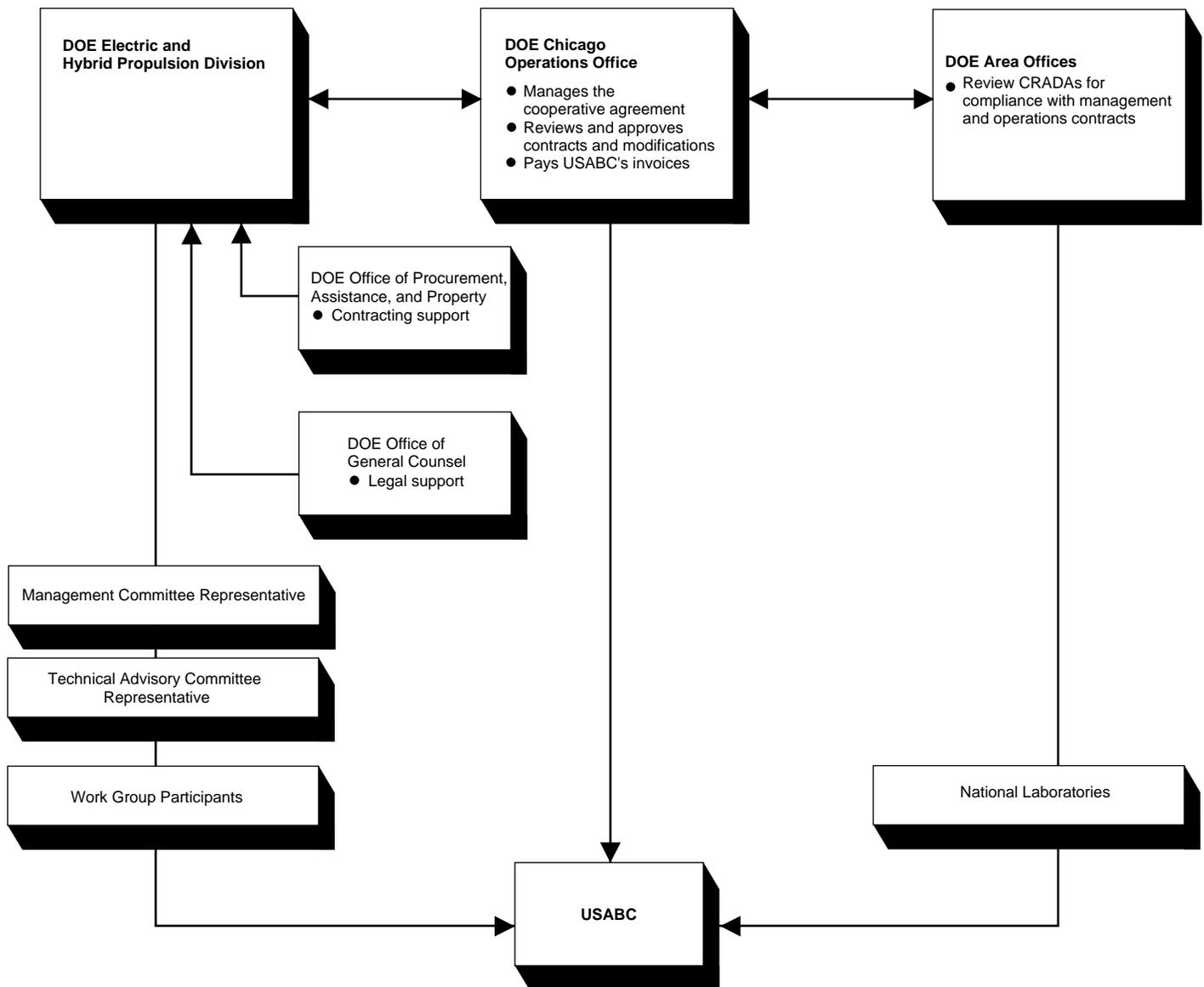
DOE's Role in USABC's Management

DOE's cooperative agreement with USABC requires DOE to be actively involved in the management of the consortium. To fulfill this requirement, DOE headquarters staff provide management and technical input into USABC's battery development efforts. Other DOE headquarters staff deal with legal and contracting issues pertaining to the consortium. DOE's Chicago Operations Office and various area offices are also involved in

Appendix I
DOE's Role in USABC's Management

supporting DOE activities with USABC. Figure I.3 illustrates the various roles played by DOE staff in the management and oversight of USABC.

Figure I.3: DOE's Role in USABC's Management



Provisions for Repaying DOE and USABC

Both DOE and the USABC partners are, under certain conditions, allowed repayment of their financial contributions to the consortium. Repayment is to be made by battery producers after batteries developed by USABC are commercialized. Provisions for repayment were negotiated between DOE and USABC in the cooperative agreement and subsequently between USABC and the battery development contractors. As required by the agreement, USABC included a provision for repaying DOE in all the battery development contracts.

Provisions for Repaying DOE

Repayment provisions outlined in the USABC cooperative agreement and in the battery development contracts stipulate that DOE's repayment is based upon (1) revenue received by USABC or its battery developers from the licensing of patents to third-party battery manufacturers and (2) any payments to USABC or its contractors upon the liquidation or winding up of USABC's business. Exempt from the repayment provisions are USABC, the USABC partners, certain companies associated with the partners, EPRI, and EPRI participants, who all can acquire a license to use the patents without paying licensing fees to DOE. In addition, a subsequent amendment to the cooperative agreement allows repayment to DOE on the basis of revenues from battery sales in addition to licensing fees. However, such a provision has been included in only one battery development contract.

DOE is to be repaid an amount no greater than the total amount of funding it provides to the program. The repayment obligation ends either after 20 years or when the entire DOE contribution has been repaid, whichever occurs first. The repayment obligation can be waived, in whole or in part, if DOE determines that repayment places USABC or its battery developers at a competitive disadvantage.

Three of the battery development contracts place an additional stipulation on DOE's ability to obtain repayment on the basis of licensing fees. That is, repayment does not begin until battery sales by the developer and/or licensee reach a specified level. As noted earlier, one contract does contain a provision granting DOE an opportunity to obtain repayment on the basis of revenues from the sale of batteries by the developer.

Provisions for Repaying the USABC Partners

The USABC partners are also entitled to obtain repayment of their financial contributions to the consortium. In most instances, the partners' ability to receive repayment depends upon two sources—battery sales revenues and license fees. In addition, most contract repayment provisions allow the

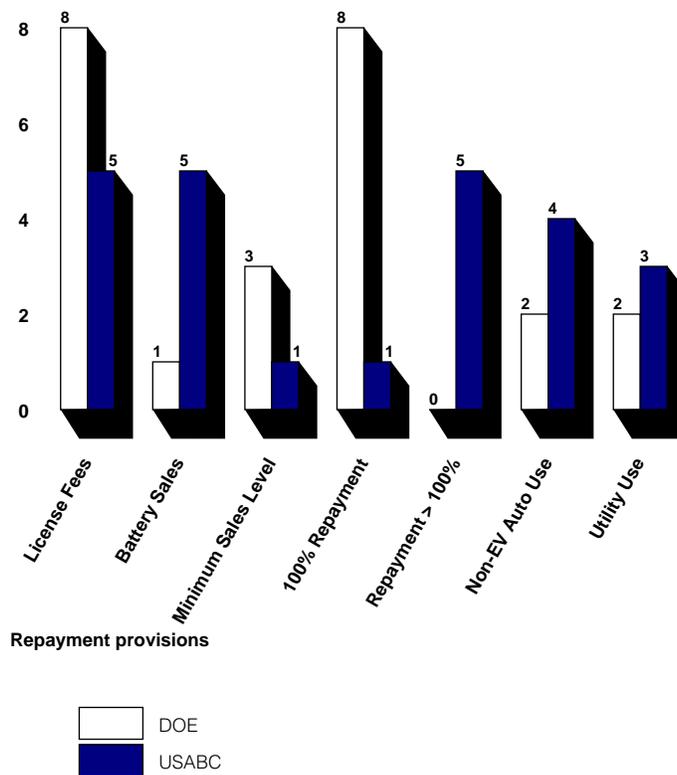
USABC partners to receive up to 20 percent more than they contributed to the battery developer. According to consortium officials, this extra repayment will compensate the USABC partners for the financial risks of supporting the battery developers. At the same time, it will enable them to compete favorably in the EV market with other automobile companies that did not support the research effort but may be able to purchase advanced batteries developed under the program at the same price as the USABC partners.

**Comparison of Provisions
for Repaying DOE and the
USABC Partners**

Figure II.1 shows some of the types of repayment provisions for DOE and the USABC partners and the number of battery development contracts containing each provision. In addition to repayment provisions based on revenues from EV battery sales and license fees, some contracts contain provisions that allow repayment on the basis of revenues from the sale of batteries for non-EV automobile applications and for use by electric utilities.

Figure II.1: Provisions for Repaying DOE and USABC

10 Number of contracts with provisions



As shown in the figure, five of the eight battery development contracts allow the USABC partners to receive repayment from revenues generated by battery sales.⁸ In addition, the repayment provisions allow the USABC partners to be repaid more than they contributed. Therefore, if the batteries developed by the USABC are commercially produced for sale, the USABC partners are likely to be repaid for their financial investment in the consortium.

The provisions for repaying DOE that are based upon licensing fees are contained in all eight battery development contracts, but only one contract contains an additional repayment provision that is based upon the sale of batteries. The extent to which the USABC or its battery development

⁸There are no provisions for USABC repayment in two of the eight battery development contracts.

contractors will choose to grant licenses to third-party manufacturers is uncertain. Consequently, any potential revenue from license fees and the corresponding amount of repayment DOE would receive could be fairly limited.

A DOE official explained that DOE's repayment terms were negotiated with USABC early in the program as part of the cooperative agreement. At that time, there were no formal requirements in place concerning what type of repayment DOE was expected to obtain. In lieu of formal guidance, the repayment provisions in the cooperative agreement were modeled upon similar provisions developed by DOE's Clean Coal program, an earlier cooperative effort between DOE and industry. The program official also explained that the USABC partners' repayment terms were negotiated later by the consortium during contract negotiations with battery developers. USABC negotiators were free to negotiate different terms from those that applied to DOE if they could convince the battery developers to agree.

Potential Patent Litigation

During our discussions with USABC's management and contractors, we became aware of a potential for future litigation over patent rights between two USABC contractors. At issue is the interpretation of patents for a promising mid-term technology. The two contractors, Ovonic Battery Company and Saft America, Inc., are both working on nickel metal hydride batteries.

Ovonic Battery Company, a small U.S.-based firm, holds a number of background patents for this technology that are based on work conducted before it contracted with USABC. Ovonic has sold licenses to other companies to use its technology in small consumer batteries. Earlier, Ovonic had charged that several Japanese electronics firms had violated its patents, and Ovonic filed patent infringement claims with the International Trade Commission. However, in December 1994, the dispute was amicably resolved, and Ovonic signed licensing agreements with these firms. In the case of the USABC program, Ovonic's officials are concerned that if Saft America eventually produces a commercial nickel metal hydride battery, some of Ovonic's patented technology may be used in this battery. They have stated that they might file suit against Saft America if this occurs and a satisfactory licensing agreement cannot be worked out.

Saft America, Inc., is a U.S.-based subsidiary of a large French battery manufacturer and the largest manufacturer of nickel cadmium batteries in the United States. Saft officials maintain that the approach they are taking to nickel metal hydride technology is significantly different from that taken by Ovonic. Therefore, they believe it is possible that any battery they ultimately produce may not use technology patented by Ovonic. However, they also stated that if it does turn out that they use Ovonic's technology, they are willing to pay Ovonic a reasonable licensing fee for such use. They believe that Ovonic's existing licensing agreements will provide precedents for determining appropriate licensing fees. Thus they believe litigation will not be necessary. In the meantime, they point out that before commercial production begins, there are no restrictions on conducting research on already patented technologies. Therefore, they are free to use Ovonic's technology in their experiments if they wish to do so.

DOE and USABC officials are aware of this potential problem, but they do not expect a real problem to develop because of the differences in the technological approaches being taken by the two firms. Moreover, they believe that any dispute that may occur down the road can be resolved by negotiating a licensing agreement, thereby avoiding litigation. However, if litigation does occur, they believe the terms of the cooperative agreement

Appendix III
Potential Patent Litigation

and USABC's contracts protect DOE and the consortium from any liability. Overall, they believe that this situation is unlikely to cause a delay in the availability of nickel metal hydride batteries in the United States. Both DOE and USABC believe that any risk involved in sponsoring both of these battery developers is outweighed by the increased chance of achieving a technological breakthrough.

USABC's Contracts and CRADAs

Overview

USABC has entered into eight contracts for the development of advanced battery technologies. Five of those involve mid-term technologies, and three involve long-term technologies. In addition to basic agreements on the dollar amount of the contract, the scope of work, schedules, and deliverables, the contracts generally include provisions on cost-sharing, ownership of intellectual property, the repayment of DOE and USABC funds, and domestic production.

The contractors generally agreed to share a portion of the costs of conducting the research and development work. While the exact percentage was determined during negotiations and varies from one company to another, the average share was expected to be about 28 percent. Repayment provisions, under which developers are required to repay some or all of the money invested by USABC and DOE, are discussed in appendix II.

Mid-Term Contractors

Table IV.1 summarizes USABC's mid-term contracts.

Table IV.1: USABC's Mid-Term Battery Development Contracts

Dollars in millions		
Contractor	Technology	Contract amount
Duracell/Varta joint venture	Lithium ion	\$17.95
Ovonic Battery Company	Nickel metal hydride	\$25.40
Saft America	Nickel metal hydride	\$20.70
Silent Power	Sodium sulfur	\$4.30
Yardney	Nickel metal hydride	\$3.45
Total		\$71.80

Of the five mid-term contractors, Ovonic Battery Company and Saft America, Inc., were among the earliest to sign contracts and continue to develop nickel metal hydride batteries. These contracts were signed during 1992. USABC believes both the competition and the varying approaches that result from having two contractors work on the same technology will increase the chances of success. In support of those two programs, Yardney is working on ways to develop a low-cost nickel electrode.

In 1993, Silent Power received a contract to work on sodium sulfur batteries. In 1994, USABC announced that it had awarded a contract to partners Duracell, Inc., and Varta Batterie AG to develop lithium ion technology. This battery has the potential to eventually exceed the

mid-term goals by a substantial margin, but because it does not have the potential to reach the long-term criteria, it is classified as a mid-term battery.

Long-Term Contractors

Table IV.2 summarizes USABC's long-term contracts.

Table IV.2 USABC's Long-Term Battery Development Contracts

Dollars in millions		
Contractor	Technology	Contract amount
Saft America	Lithium iron disulfide	\$17.3
W.R. Grace	Lithium polymer	\$27.4
3M	Lithium polymer	\$32.9
Total		\$77.6

Of USABC's three long-term contracts, the two with W.R. Grace and 3M involve lithium polymer technology. The two firms are taking somewhat different approaches to the same technology, and USABC hopes the competition between them will bring about rapid results. Both companies are working with partners. Grace heads a team that also includes Johnson Controls and a number of smaller participants. 3M is teamed with Hydro-Quebec, a Canadian utility that has worked extensively on lithium polymer technology.

Meanwhile, Saft America, the only company with both a mid-term and long-term contract, is working on lithium iron disulfide (or, more specifically, lithium-aluminum iron disulfide) batteries. These batteries have very high energy potential but also present serious corrosion and life expectancy challenges because they operate at extremely high temperatures.

Cooperative Research and Development Agreements With National Laboratories

USABC has entered into a series of cooperative research and development agreements with five of DOE's national laboratories. In some cases, because the laboratories had experience in research and development of some of the technologies of interest to the consortium, it made sense to take advantage of their experience. In other cases, the laboratories had the equipment and expertise needed to conduct independent testing of battery hardware and give USABC consistent and objective test results on deliverables provided by a variety of battery developers. This testing capability has been useful in screening and selecting contractors for the program. It has also been valuable in assessing progress by the developers

Appendix IV
USABC's Contracts and CRADAs

once they have been awarded contracts and have begun producing prototype hardware. Table IV.3 summarizes USABC's CRADAs with the national laboratories. As the table shows, some laboratories do only testing or development work, but two (Argonne and Sandia) are involved in both types of activity.

Table IV.3: USABC's CRADAs With DOE's National Laboratories

Dollars in millions		
National laboratory	Tasks	CRADA amount
Argonne National Laboratory	Test mid-term nickel metal hydride and sodium sulfur batteries	\$5.9
	Develop supporting technologies for long-term lithium iron disulfide battery	\$7.2
Idaho National Engineering Laboratory	Test mid-term sodium sulfur batteries	\$0.9
	Test long-term lithium polymer batteries	\$0.1
Lawrence Berkeley National Laboratory	Develop supporting technologies for long-term lithium polymer battery	\$4.3
National Renewable Energy Laboratory	Develop thermal enclosure for high temperature sodium sulfur and lithium iron disulfide batteries	\$3.9
Sandia National Laboratory	Test mid-term sodium sulfur batteries and develop supporting technologies for long-term lithium polymer batteries	\$9.4
Total		\$31.7

USABC's Long-Term and Mid-Term Goals

USABC established separate long-term and mid-term goals for advanced batteries, measured according to a variety of criteria that measure critical battery characteristics such as power, durability, and cost. While all of the criteria are important to achieve viable advanced batteries, this appendix discusses five key criteria that the automobile companies believe are essential to offering EVs that will meet consumers' needs. Table V.1 identifies the mid-term and long-term goals for each criterion. An explanation of the five criteria follows the table.

Table V.1: Key USABC Advanced Battery Technology Goals

Criteria	Mid-term goals	Long-term goals
Specific power	150-200 watts per kilogram	400 watts per kilogram
Specific energy	80 to 100 watt-hours per kilogram	200 watt-hours per kilogram
Calendar life	5 years	10 years
Cycle life	600 cycles	1,000 cycles
Ultimate price	Less than \$150 per kilowatt-hour	Less than \$100 per kilowatt-hour

Specific power is a measure of the amount of power provided by a given battery mass. This goal is related to EV performance characteristics such as acceleration and hill-climbing ability.

Specific energy is a measure of the amount of total energy contained in a given battery mass. This goal is related to the crucial EV characteristic of driving range. Generally, the higher the specific energy of the battery, the more miles the vehicle will be able to travel between recharges.

Calendar life refers to the number of years a battery will last, irrespective of the number of times it is charged and recharged. This measure is important because a battery's performance can deteriorate over time because of factors other than use. For example, the performance of batteries that operate at very high temperatures can be reduced by the corrosion that takes place as time passes.

Cycle life is a measure of the number of times a battery can be discharged and recharged before its performance deteriorates to unacceptable levels. This characteristic will determine how much an EV can be used before its battery pack needs replacement, and its impact on a battery's life expectancy depends upon daily usage patterns. For example, in a heavily used EV, a battery just meeting the mid-term goal of 600 cycles would last fewer than 2 years if it were discharged and recharged each day. On the

other hand, DOE officials believe that actual EV usage patterns will require recharging only every 2 to 4 days, so that mid-term batteries would last much longer than 2 years.

Ultimate price is a measure of the cost EV manufacturers would pay per unit of energy once vehicle-sized battery packs are in large-scale production—at least 10,000 units annually. This criterion is critical to the automakers' ability to offer EVs at prices that will make them competitive with conventional vehicles.

DOE's Appropriations for USABC

Table VI.1 shows the amounts of actual or anticipated appropriations since 1991 for DOE's battery development programs. The portions of the total appropriations not allocated to USABC are used for several other purposes, including overhead expenses, preparation of reports, and research on critical battery technologies and other high-power storage devices in support of USABC contracts and/or the Partnership for a New Generation of Vehicles.⁹ The amounts in the table are based on information provided by DOE's manager of the Electric and Hybrid Propulsion Division.

Table VI.1: DOE's Appropriations Allocated to USABC

Dollars in millions			
Fiscal year	Total battery development appropriation	Net amount to USABC	Cumulative amount to USABC
1991	\$15.9	\$6.30	\$6.30
1992	\$27.0	\$20.87	\$27.17
1993	\$31.5	\$21.87	\$49.04
1994	\$36.2	\$26.00	\$75.04
1995	\$28.3	\$20.50 ^a	\$95.54
1996	\$31.6 ^a	\$19.80 ^a	\$115.34
1997	^b	\$15.66 ^c	\$131.00

^aAmounts planned by DOE. For 1996, in addition to the \$19.8 million to continue the ongoing USABC program, DOE also expects to receive an additional \$10 million to develop advanced high-power energy storage devices for the Partnership for a New Generation of Vehicles. Vehicles developed by that program may need a different type of energy storage device than that needed by pure EVs. This new effort is expected to be managed by USABC but will be separate from its EV battery development program.

^bThe total amount that DOE plans to request for battery development in 1997 is unknown at this time.

^cThe amount that would be needed in DOE's 1997 budget to carry out USABC's plan of spending the entire \$262 million program budget through 1997.

As table VI.1 shows, as of fiscal year 1995, DOE had received appropriations of nearly \$96 million for USABC. Meanwhile, DOE's share of the funds expended through March 1995 was approximately \$61 million. Spending was heavier on mid-term contracts early in the program. However, the portion spent on long-term work has gradually increased as the long-term contracts get up to speed while the mid-term contracts near completion. Overall, USABC expects the pace of spending to accelerate this year, and therefore most of DOE's accumulated appropriations will be paid out under the existing contracts and CRADAs during 1995.

⁹The Partnership for a New Generation of Vehicles is a joint government/industry effort aimed at developing vehicles with greatly improved energy efficiency and lower emissions.

Comments From the Department of Energy



Department of Energy

Washington, DC 20585

August 1, 1995

Mr. Victor S. Rezendes
Director, Energy and Science Issues
U.S. General Accounting Office
Washington, DC 20548

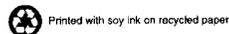
Dear Mr. Rezendes:

Thank you for your letter dated July 18, 1995, to Secretary O'Leary regarding the General Accounting Office draft report GAO/RCED-95-234 titled "Electric Vehicles: Efforts to Complete Advanced Battery Development Will Require More Time and Funding."

The Department believes that the draft report underestimates the benefits of the United States Advanced Battery Consortium (USABC) mid-term battery development program. The mid-term technology that has been developed by the USABC offers significant advantages over current batteries in both vehicle operating range and performance. By more than doubling the available energy that can be stored on-board the vehicle, energy efficient light duty vans and passenger cars can achieve a reliable range from 70 to over 100 miles, respectively, on a single charge. Field tests of very efficient vehicles, such as the General Motors Impact, have demonstrated a range of 140 miles with nickel metal hydride mid-term batteries in combined city and highway driving. The performance and range provided by these mid-term batteries will enable the industry to initiate commercialization of electric vehicles that will be attractive to a large number of fleet owners and commercial vehicle operators, as well as to a segment of the general public.

Although the current projected cost goals for the mid-term batteries may preclude electric vehicles from being economically competitive with conventional cars in the near term, secondary markets for these technologies provide a strong incentive for further research that could help bring these costs down to the point where the cost differential would be negligible when spread over all vehicle sales. Some of the higher value secondary markets may also provide an outlet for a portion of the early higher cost initial production batteries, as well as help accelerate the production ramp-up to levels where costs can be more quickly minimized through economies of scale.

The goals established for the long-term batteries that the USABC currently has under development will enable electric vehicles to be fully competitive with conventional vehicles in terms of both cost and performance. As your report has stated, the feasibility of these long-term technologies is not assured. When the USABC program was first initiated in 1991, the goal was to demonstrate laboratory feasibility of the long-term technologies within the



Appendix VII
Comments From the Department of Energy

first four years. Although that goal has now been achieved, these batteries are still many years away from commercial reality. In the meantime, vehicles with mid-term batteries can adequately fulfill the needs of many customers and their introduction will begin to help our urban areas resolve their air quality problems.

Advanced battery technology is changing rapidly in response to a very strong consumer market for systems with much greater energy storage. In particular, the strong consumer market for rechargeable batteries has resulted in rapid introduction of lithium ion and lithium polymer technology. Both these technologies offer the potential to approach the long-term goals. The Japanese New Energy and Industrial Technology Development Organization is committed to a major battery development effort with equivalent long-term goals. We believe these external factors show that considerable worldwide resources, beyond the Department's program with USABC, are devoted to achievement of goals similar to those established by the USABC for the long-term.

The Department also notes that the budget for the USABC has to be placed in the perspective of research and development of other technical options for the automotive industry for which the Department is responsible. Although the USABC was the first of several large programs the Department has developed with the automotive industry, it is not the only one. The Department also has significant research and development efforts in hybrid vehicle systems, fuel cell technology, and advanced transportation materials. In each case, the industry participants in these programs seek funding from the Department for their particular activity. The Department works with industry to more wisely allocate the funds appropriated. Toward this end, the Department staff has actively encouraged the USABC to "stretch out" its current funding, and to terminate programs that are not productive. At the same time, industry has taken steps to make the USABC program more efficient and productive, thus reducing its overall costs. The Department believes the USABC's plan for seeking additional funds is prudent and well considered.

The Department accepts the GAO recommendation to "give more careful consideration to the document Lessons Learned Under the United States Advanced Battery Consortium to determine whether any of its recommendations should be implemented and develop an action plan for implementing those that are warranted."

Appendix VII
Comments From the Department of Energy

Minor editorial changes have been provided to the General Accounting Office under separate cover. The Department hopes that the comments in both letters will be helpful in the preparation of the final report.

Sincerely,



Thomas J. Gross
Deputy Assistant Secretary
for Transportation Technology
Energy Efficiency and Renewable Energy

Objectives, Scope, and Methodology

The objectives of the review were to determine (1) the progress that the United States Advanced Battery Consortium has made toward reaching its long-term and mid-term goals; (2) the funding that has been spent thus far and the additional amounts, if any, that will be needed; and (3) DOE's role in managing the USABC.

To address these objectives, we conducted extensive interviews with officials of DOE, USABC, the Electric Power Research Institute, USABC contractors, national laboratories, and several other interested parties outside of USABC. We also obtained and reviewed pertinent documents from these sources, as discussed below. The following list identifies the agencies and organizations contacted.

Department of Energy

- Program management officials in DOE's Electric and Hybrid Propulsion Division.
- Other DOE headquarters officials responsible for procurement and patent issues.
- Contracting officials and legal counsel in DOE's Chicago Operations Office.
- Representatives of DOE's Argonne Area Office, which oversees the work of DOE's Argonne National Laboratory.

United States Advanced Battery Consortium

- Officials of the USABC Management Committee, including the chairman and treasurer.
- Legal counsel for USABC.
- Four USABC program managers who are responsible for managing specific battery development contracts and/or CRADAs and are also members of USABC's Technical Advisory Committee.

Electric Power Research Institute

- An official of the Electric Power Research Institute who represents the electric utilities on the USABC Management Committee.

USABC Contractors

- Officials of two battery firms—Ovonic Battery Company and Saft America, Inc.—which are conducting research and development under contracts with USABC.

DOE's National Laboratories

- Officials of the Argonne National Laboratory and the National Renewable Energy Laboratory, which are conducting battery research and testing under CRADAS with USABC.

Interested Parties Outside USABC

- A representative of an independent producer of EVs, U.S. Electricar, which converts several conventional vehicles, including those of the big three automobile companies, to electric drive.
- A representative of the Advanced Lead-Acid Battery Consortium, which sponsors research and development of advanced lead-acid batteries.
- An official of Electrosorce, Inc., a major producer of advanced lead-acid batteries for EVs.

Department of Defense

- Officials of the Advanced Research Projects Agency, which sponsors research on advanced lead-acid batteries for EVs and demonstrations of EVs using those batteries.
- An official of the Office of Naval Research, which sponsors research on battery technologies for military applications.

To determine the progress that USABC had made toward reaching its long-term and mid-term goals, we interviewed DOE, USABC, and national laboratory officials to discuss the status of work in developing the battery technologies and their expected completion dates and reviewed applicable progress reports. We also met with two battery development firms—Ovonic Battery Company and Saft America, Inc.—to discuss their progress to date. These two firms were selected because they were the first to sign contracts with USABC and appeared to have made the greatest progress in developing a mid-term battery. In addition, Saft is developing a long-term battery.

To address the objective on funding issues, we interviewed DOE and USABC officials to discuss the funds appropriated and allocated to the development of advanced batteries, the expenditures to date, and the need for additional funds to complete the work. We reviewed pertinent program budgets, appropriation documents, and expenditure reports.

To address the objective on management issues, we interviewed many of the previously listed officials to discuss DOE's roles and responsibilities in relation to the other consortium members and DOE's procedures, processes, and actions taken to oversee the management of federal funds and the scope of the work being carried out to develop advanced batteries.

We reviewed the cooperative agreement—which specifies the roles and responsibilities, organizational structure, funding and cost-sharing, and rights to technology when developed, of DOE and the participating industry groups, and we reviewed the provisions of battery development contracts dealing with the repayment of federal funds. We also reviewed the management issues identified in the document entitled Lessons Learned Under the USABC. In addition, we reviewed an independent public accounting report that looked into the cost controls of one of the battery developers.

Major Contributors to This Report

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Jackie A. Goff, Senior Attorney

Related GAO Products

Electric Vehicles: Likely Consequences of U.S. and Other Nations' Programs and Policies (GAO/PEMD-95-7, Dec. 30, 1994).

Alternative-Fueled Vehicles: Progress Made in Accelerating Federal Purchases, but Benefits and Costs Remain Uncertain (GAO/RCED-94-161, July 15, 1994).

Energy and Science Reports and Testimony: 1993 (GAO/RCED-94-176W, June 1994).

Energy: Bibliography of GAO Documents January 1986-December 1989 (GAO/RCED-90-179, July 1990).

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